AERO - AEROSPACE ENGINEERING

AERO 601 Advanced Aerodynamics
Credits 3. 3 Lecture Hours.
Theoretical and approximate solutions for steady and unsteady incompressible flows and steady transonic flows; applications to airfoil, wing and whole-vehicle aerodynamics; approximate methods for boundary layers; introduction to aerodynamic design concepts; design of swept wings and delta wings and control surfaces.
Prerequisite: Approval of instructor.

AERO 602 The Theory of Fluid Mechanics
Credits 3. 3 Lecture Hours.
Entry-level theory of fluid mechanics with emphasis on viscous subsonic flows; governing principles and equations, exact solutions to simple problems of the Navier-Stokes equations, similarity solutions and boundary layer theory; flow stability, transition and turbulence.
Prerequisite: Graduate classification and approval of instructor.

AERO 603/MEMA 602 Continuum Mechanics
Credits 3. 3 Lecture Hours.
Development of field equations for analysis of continua (solids as well as fluids); kinematics, constitutive behavior of solids and fluids; applications to aerospace engineering problems involving solids and fluids.
Prerequisite: Graduate classification.
Cross Listing: MEMA 602/AERO 603.

AERO 605/MEEN 603 Theory of Elasticity
Credits 3. 3 Lecture Hours.
Analysis of stress and strain in two- and three-dimensions, equilibrium and compatibility equations, strain energy methods; torsion of noncircular sections; flexure, axially symmetric problems.
Prerequisite: Graduate or senior undergraduate standing.
Cross Listing: MEEN 603/AERO 605.

AERO 606 Multifunctional Materials
Credits 3. 3 Lecture Hours.
In-depth analysis of multifunctional materials and composites, and their novel applications.
Prerequisites: MEMA 602/AERO 603/MEMA 603, MSEN 601.
Cross Listing: MEMA 606 and MSEN 606.

AERO 608 Nanomechanics
Credits 3. 3 Lecture Hours.
Application of mechanics concepts to nano-scale behavior of materials. Review of continuum mechanics; Extensions to generalized continua; Nonlocal elasticity; Nano-scale plasticity. Focus on multi-scale modeling: Dislocation Dynamics; Quasi-Continuum method; Molecular dynamics with introductions to quantum mechanics and statistical mechanics.
Prerequisite: AERO 603/MEMA 602.
Cross Listing: MEMA 608 and MSEN 608.

AERO 609 Sustainability Metrics and Life Cycle Assessment in Engineering
Credits 3. 3 Lecture Hours.
Concepts of sustainability with associated metrics; application of systems engineering tools to facilitate assessment of viable options on products and processes; assessment of impact on the entire biosphere; product life cycle analysis.
Prerequisite: Graduate classification.

AERO 615 Computational Fluid Dynamics for Aerospace Applications
Credits 3. 3 Lecture Hours.
Methods for solving internal and external flow problems; viscous and inviscid compressible flow, Euler, Navier-Stokes and Large Eddy Simulation solvers, boundary conditions.
Prerequisite: MATH 601 or approval of instructor.

AERO 616 Damage and Failure in Composite Materials
Credits 3. 3 Lecture Hours.
Mechanisms and models related to damage and failure in composite materials subjected to mechanical loads.
Prerequisite: Courses in composite materials, elasticity.
Cross Listing: MEMA 616 and MSEN 636.

AERO 617/MEMA 625 Micromechanics
Credits 3. 3 Lecture Hours.
Introduction to coupled field theories: constitutive response of materials with thermal and electromagnetic coupling; microstructural changes due to phase transformations; shape memory alloys; piezoelectric and magnetostriective materials; active polymers and solutions; Micromechanics of active composites.
Prerequisites: MEMA 602/AERO 603, or AERO 603/MEMA 602, AERO 605/MEEN 603.
Cross Listing: MEMA 625/AERO 617.

AERO 618/MEMA 626 Mechanics of Active Materials
Credits 3. 3 Lecture Hours.
Introduction to coupled field theories: constitutive response of materials with thermal and electromagnetic coupling; microstructural changes due to phase transformations; shape memory alloys; piezoelectric and magnetostriective materials; active polymers and solutions; Micromechanics of active composites.
Prerequisites: MEMA 602/AERO 603.
Cross Listing: MEMA 626/AERO 618.

AERO 620 Unsteady Aerodynamics
Credits 3. 3 Lecture Hours.
Theoretical formulation of unsteady airfoil theory and techniques used for determining airloads on oscillating lift surfaces; exact solutions and various approximations presented and evaluated; application to problems of unsteady incompressible, subsonic and transonic flows about airfoils and wings.
Prerequisite: Approval of instructor.

AERO 621 Aeromechanics of Wind Turbines
Credits 3. 3 Lecture Hours.
Solid and fluid mechanics concepts applied to aerodynamics and aeroelasticity of wind turbine blades; failure analysis and structural design; composites and hybrid materials.
Prerequisite: Graduate Classification.

AERO 622 Spacecraft Dynamics and Control
Credits 3. 3 Lecture Hours.
Elements of analytical dynamics; modeling different types of spacecraft and control systems; sensors, and actuators; stability; control system design; effects of flexibility; attitude and orbital coupling; environmental effects.
Prerequisites: AERO 422 or ECEN 420.
AERO 623 Optimal Spacecraft Attitude and Orbital Maneuvers
Credits 3. 3 Lecture Hours.
Application of optimization and optimal control techniques to spacecraft maneuver problems; computation of open loop and feedback controls for linear and nonlinear spacecraft dynamical systems; low-thrust and impulsive control, discretization methods, case studies.
Prerequisite: AERO 423 or equivalent.

AERO 624 Celestial Mechanics
Credits 3. 3 Lecture Hours.
Analytical and numerical methods for computing spacecraft orbits under the influence of gravitational, aerodynamic, thrust and other forces; Keplerian two-body problem, perturbation methods, orbit determination, navigation and guidance for aerospace vehicles.
Prerequisite: AERO 423 or equivalent.

AERO 625 Modern Control of Aerospace Systems
Credits 3. 3 Lecture Hours.
Linear and nonlinear controllers for aircraft and spacecraft; state and output feedback of sampled-data control systems; feedback linearization and dynamic inversion; direct sampled-data design using optimal MIMO techniques; sensing considerations, sources and modeling of uncertainties unique to aircraft and spacecraft, robustness analysis.
Prerequisite: AERO 422 or equivalent.

AERO 626 Estimation of Dynamic Systems
Credits 3. 3 Lecture Hours.
Traditional concepts and recent advances in estimation related to modern dynamic systems found in aerospace disciplines; least squares estimation, state estimation, nonlinear filtering, aircraft position and velocity tracking, attitude determination of spacecraft vehicles, gyro bias estimation and calibration.
Prerequisites: AERO 310 or equivalent; STAT 211 or equivalent.

AERO 627 Principles of Structural Dynamics
Credits 3. 3 Lecture Hours.
Examination of flexible structures through a review of single degree-of-freedom dynamical systems followed by an in-depth study of continuous and multiple degree-of-freedom systems; emphasis on discrete modeling of structures for vibration analysis and dynamic analysis, with minimal development of methods such as finite elements.
Prerequisite: Graduate classification.

AERO 628 Advanced Spacecraft Dynamics and Control
Credits 3. 3 Lecture Hours.
Review of fundamental principles; introduction to alternate and advanced methods of dynamics and control for aerospace systems; alternate methods for generating and analyzing equations of motion; techniques for complex multibody systems; variable speed control moment gyros; method of quadratic modes; focus on modeling techniques for aerospace systems.
Prerequisite: AERO 622.

AERO 629 Experimental Aerodynamics
Credits 3. 3 Lecture Hours.
Review of fundamental principles in aerodynamics; basics of instrumentation, electronics, data-acquisition; experimental techniques in aerodynamics/fluid mechanics; pressure, skin friction, force and velocity measurement techniques in wind and water-tunnel testing; conventional and novel techniques in data-processing and systems modeling; smart systems in experimental aerodynamics.
Prerequisite: AERO 601.

AERO 630 Introduction to Random Dynamical Systems
Credits 3. 3 Lecture Hours.
Building on basic probability theory, course covers theory and applications of discrete and continuous random processes. Particular attention shall be paid to the response of dynamical systems (discrete, linear and non-linear), to random input processes and their application to Engineering Systems.
Prerequisite: Graduate classification.

AERO 631 Model Predictive Control for Aerospace Systems
Credits 3. 3 Lecture Hours.
Nonlinear optimal control and optimization, optimal control theory, dynamical systems stability and control, approximation theory, convex optimization; control of engineering systems with state and control constraints with parametric uncertainty; formulate optimal control problems, solve as nonlinear programming problems using available solvers; requires background in control theory.
Prerequisites: Graduate classification and AERO 623 or comparable course.

AERO 632 Design of Advanced Flight Control Systems - Theory and Application
Credits 3. 3 Lecture Hours.
Modeling, analysis, design and implementation of advanced flight control problems, specifically aerospace engineering applications; includes choice of controlled variables, reduction of controlled variables, design methodology, computational framework, implementation issues, and software environments using various toolboxes.
Prerequisites: Graduate classification and approval of instructor.

AERO 633 Advanced Aerospace Multibody Dynamics
Credits 3. 3 Lecture Hours.
Techniques for modeling, simulation, and analyzing multibody dynamical systems; includes development of kinematic expressions for articulating bodies, adding and constraining degrees of freedom through mappings; familiarization with industry codes, such as DISCOS, appreciation of learned techniques on various systems, including omni-directional vehicles, Stewart platforms, and gyroscopically-stabilized walking robots.
Prerequisites: AERO 622 or graduate classification and approval of instructor.

AERO 640 Turbulence Processes
Credits 3. 3 Lecture Hours.
Fundamentals of conservation, Lagrangian, transformation, variance properties; flow features: laminar, transition, turbulence regimes, characteristics, spectrum; statistical (filter/average) description: scales, Reynolds, arbitrary averaging, realizability; elementary turbulence processes: viscous, advective/inertial, role of pressure; elementary process models, viscous RDT, RDT for velocity gradients, equipartition of energy, restricted Euler equations; isotropic, homogeneous turbulence. May be taken 2 times for credit.

AERO 641 High-Speed Combustion for Propulsion
Credits 3. 3 Lecture Hours.
Study topics in combustion relevant to high-speed subsonic/supersonic air-breathing propulsion; emphasis on the structure of detonations and the operation of combustors under supersonic conditions; structure of shock-waves and the mixing/chemical kinetics that take place in high speeds.
Prerequisite: Graduate classification.
AERO 642 Laser Diagnostics for Combustion and Propulsion
Credits 3.3 Lecture Hours.
Laser diagnostics topics as applied to combustion and propulsion; brief exposition of fundamental electromagnetic theory; practice of basic experimental laser techniques used to measure thermochemistry; basic implementation of Raman and Rayleigh scatterings; Laser-Induced Fluorescence (LIF); detection methods, optical systems, noise contributions, and signal enhancement techniques will be discussed.
Prerequisite: Graduate classification.

AERO 643 High-Performance Computational Fluid Dynamics
Credits 3.3 Lecture Hours.
Numerical simulations of fluid dynamics problems on massively parallel computers; focus on Direct Numerical Simulations (DNS) where all dynamically relevant scales are resolved; elements of both high-performance computing (HPC) and numerical methods to solve incompressive and compressible flows.
Prerequisite: AERO 615 or approval of instructor.

AERO 645/MSEN 645 Failure Mechanics of Engineering Materials
Credits 3.3 Lecture Hours.
Introduction and integration of key experimental, theoretical and computational aspects of failure in engineering materials, including metals, alloys and polymers; brittle fracture, ductile fracture and brittle-to-ductile transitions.
Prerequisites: Graduate classification; MSEN 601.
Cross Listing: MSEN 645/AERO 645.

AERO 649/MEMA 649 Generalized Finite Element Methods
Credits 3.3 Lecture Hours.
Systemic introduction to the theory and practice of generalized finite element (FE) methods, including GFEM, the hp-cloud method, particle methods, and various meshless methods with similar character; precise formulation of the methods are presented; known theoretical results for convergence; important issues related to implementation, issues of numerical integration.
Prerequisite: Graduate classification.
Cross Listing: MEMA 649/AERO 649.

AERO 650 Spacecraft Attitude Determination
Credits 3.3 Lecture Hours.
Spacecraft attitude determination systems; attitude and error parameterizations, attitude sensors, data processing and calibration; introduction to single- and three- axis attitude determination and to optimal attitude and error estimation: ECI motion and time definitions.
Prerequisite: AERO 423 or equivalent.

AERO 651 Human Spaceflight Operations
Credits 3.3 Lecture Hours.
Essential aspects of human spaceflight operations as performed NASA; in-depth understanding of the state-of-the-art in spacecraft operations, including spacecraft systems, ground and launch operations, mission management and on-orbit activities such as science, robotics, spacewalking, and human health maintenance; applications to future space systems.
Prerequisite: Graduate classification.

AERO 655 Helicopter Aerodynamics
Credits 3.3 Lecture Hours.
Hovering theory, hovering and vertical flight performance, factors affecting hovering and vertical flight performance, auto-rotation in vertical descent, concepts of blade motion and control, aerodynamics of forward flight, forward flight performance, operational envelope and introduction to conceptual design of helicopters.
Prerequisites: Grade of C or better in AERO 222, AERO 301, and AERO 310; graduate classification.

AERO 660 Nonlinear Flight Dynamics
Credits 3.3 Lecture Hours.
Nonlinear equations of motion for coupled aircraft motions; coupled aerodynamic phenomena; application of the direct method of Lyapunov to nonlinear aircraft motions; elastic airplane equations of motion.
Prerequisite: AERO 421 or approval of instructor.

AERO 661 Optical Methods in Aerospace Engineering
Credits 3.3 Lecture Hours.
Analysis and design of imaging and interferometric instruments for flight in and above the atmosphere and ground-based observation of orbiting objects; assessment of optical component and system performance.
Prerequisite: Graduate classification.

AERO 670 Turbulence Modeling
Credits 3.3 Lecture Hours.
Identification of physical features that render Navier-Stokes equation difficult to compute or model; includes Reynolds-averaged and filtered Navier-Stokes equations for unresolved stresses; development of closure models for pressure-strain correlation, dissipation and turbulent transport Reynolds; algebraic Reynolds stress modeling, Large Eddy Simulations (LES) and hybrid methods; validation and prediction studies.
Prerequisites: AERO 640 and graduate classification or approval of instructor.

AERO 672 Perturbation Methods in Mechanics
Credits 3.3 Lecture Hours.
Develop approximate solutions to algebraic, differential, and integral equations; analysis of nonlinear oscillations, nonlinear waves, and boundary-layers; emphasis on combined numerical/perturbations techniques and reducing Partial Differential Equation (PDE) to Ordinary Differential Equation (ODE).
Prerequisites: Graduate classification in aerospace, mechanical or civil engineering.

AERO 673 Boundary Layer Stability and Transition
Credits 3.3 Lecture Hours.
Analytical, numerical, and experimental methods for the stability of bounded shear flows; includes techniques for estimating transition to turbulence and the control of transition through laminar flow control.
Prerequisites: Graduate classification and AERO 601, 602, or 603 or approval of instructor.

AERO 674 Hypersonic Flow
Credits 3.3 Lecture Hours.
Theoretical formulation of hypersonic flow theory; techniques for hypersonic flowfield analysis; high temperature effects, including both equilibrium and nonequilibrium flows; classical and modern computational methods.
Prerequisite: AERO 303 or equivalent.
AERO 676 Aerothermochemistry  
**Credits 3. 3 Lecture Hours.**  
Fundamentals of kinetic theory, chemical thermodynamics and statistical mechanics; applications to high temperature chemically reacting equilibrium and nonequilibrium aerodynamic flows.  
**Prerequisite:** AERO 303 or equivalent.

AERO 681 Seminar  
**Credit 1. 1 Lecture Hour.**  
Selected research topics presented by the faculty, students and outside speakers.  
**Prerequisite:** Graduate classification.

AERO 684 Professional Internship  
**Credits 1 to 4. 1 to 4 Other Hours.**  
Engineering research and design experience at government or industry facilities away from the Texas A&M campus; design projects supervised by faculty coordinators and personnel at these locations; projects selected to match student's area of specialization.  
**Prerequisites:** Graduate classification and approval of committee chair and department head.

AERO 685 Directed Studies  
**Credits 1 to 12. 1 to 12 Other Hours.**  
Special topics not within scope of thesis research and not covered by other formal courses.  
**Prerequisite:** Graduate classification in aerospace engineering.

AERO 689 Special Topics in...  
**Credits 1 to 4. 1 to 4 Lecture Hours.**  
Selected topics in an identified area of aerospace engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

AERO 691 Research  
**Credits 1 to 23. 1 to 23 Other Hours.**  
Technical research projects approved by department head.